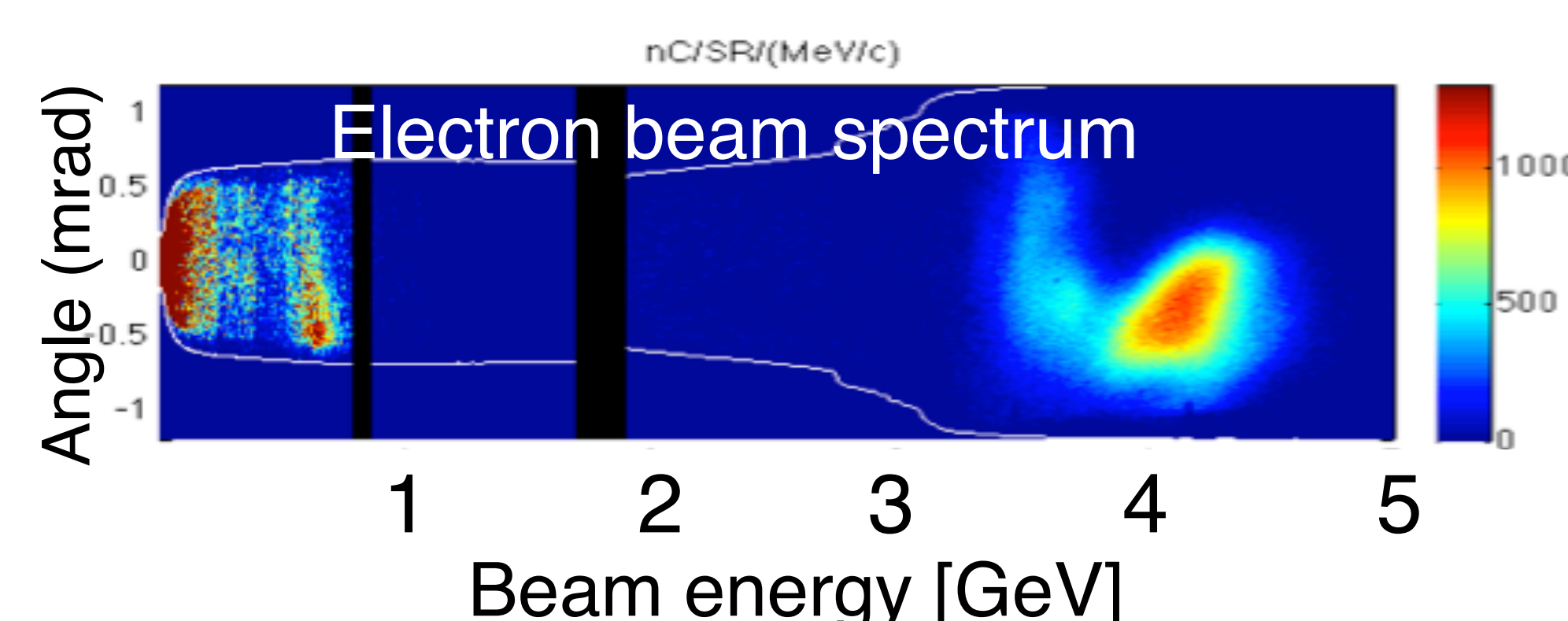BELLA

Ultra-intense laser-matter interactions with the BELLA-i PW laser user facility

Wim Leemans, Eric Esarey, Thomas Schenkel, Sven Steinke, Stepan Bulanov, Qing Ji
Lawrence Berkeley National Laboratory, Berkeley, CA 94720

BELLA is a high rep rate PW laser and we use it for high intensity laser plasma acceleration experiments
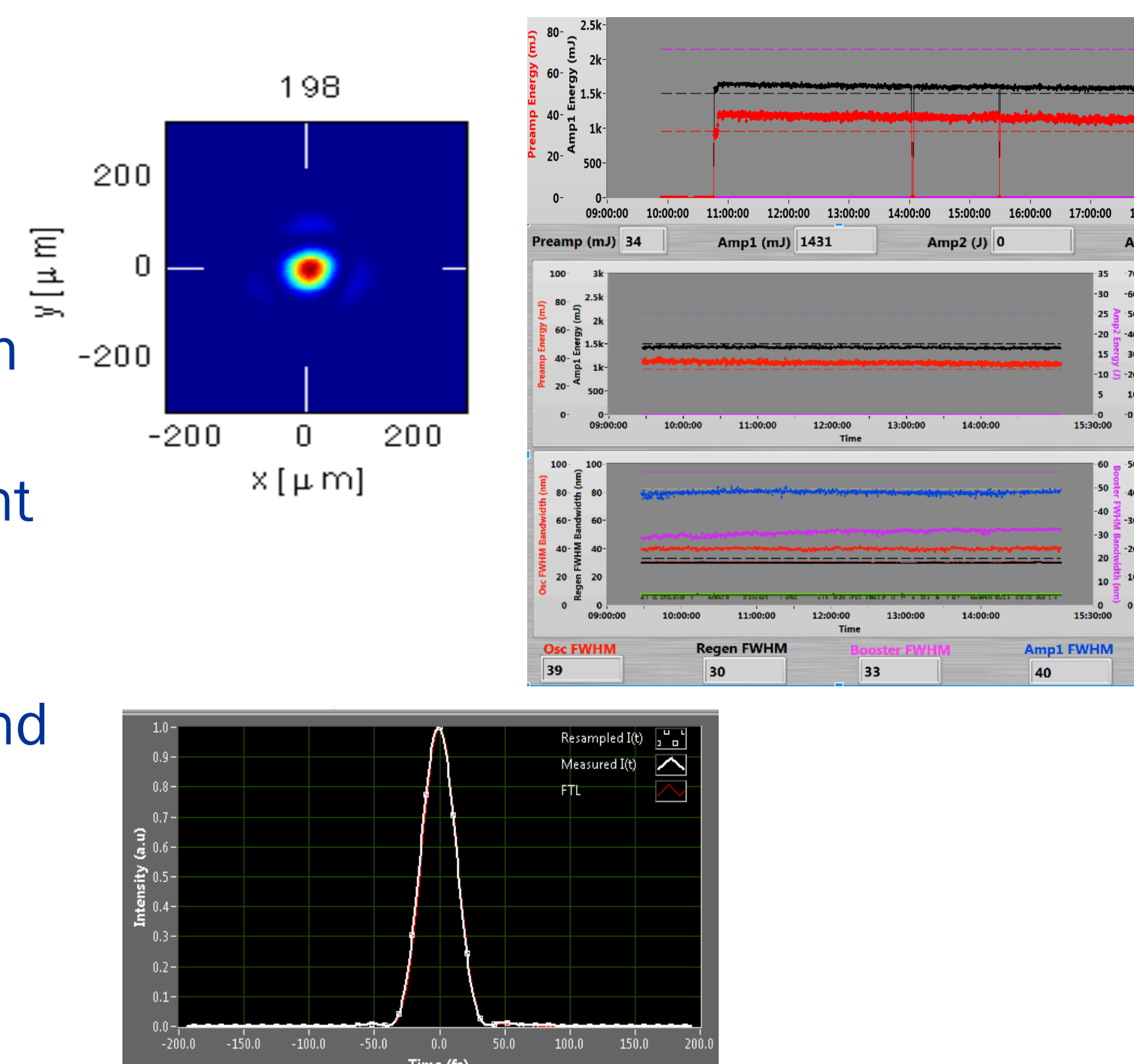
- Unique tool for development of 10 GeV laser plasma accelerator and other collider relevant concepts

Electron beam spectrum

nC/SR/(MeV/c)
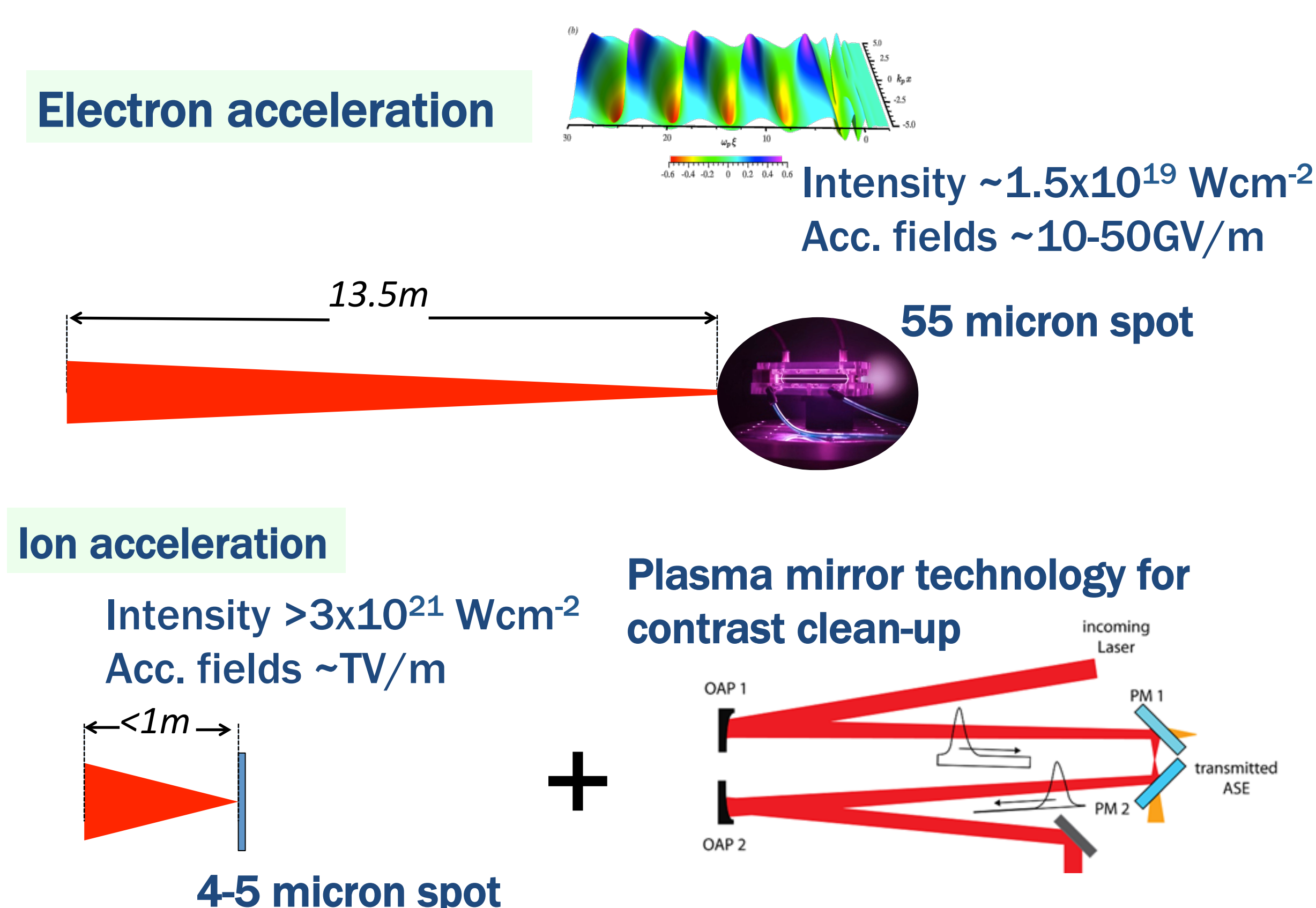
Angle (mrad) — Beam energy [GeV]

- First commercial Petawatt laser operating at > 42 J in ~30 fs at 1 Hz
- Record electron beam energies of 4.5 GeV were recently demonstrated, W.P. Leemans et al., PRL 2014

Laser quality and experienced operations team are key to successful experimental campaigns
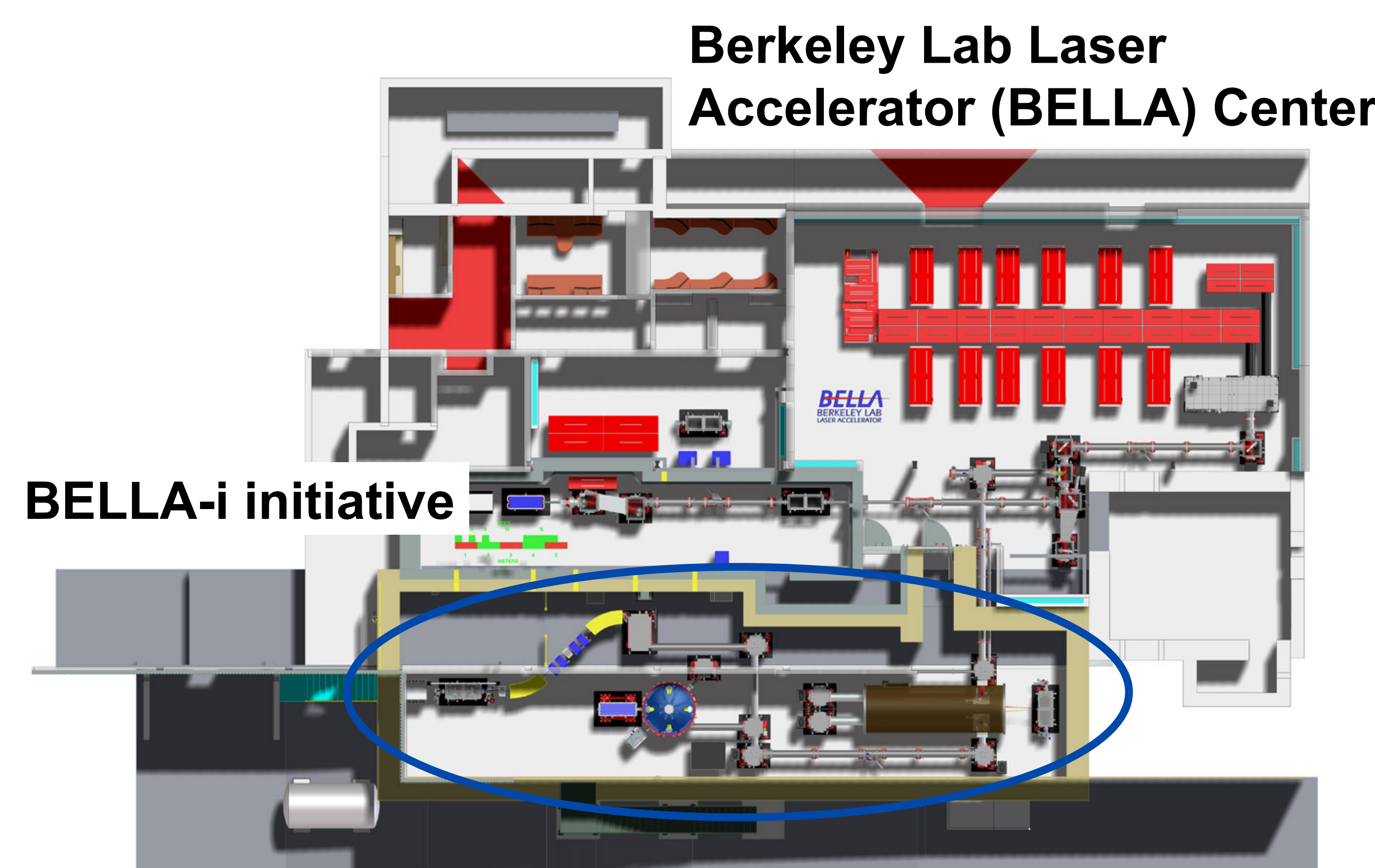
- Front-end laser energy stability: Stable >7 hours
- High mode quality
- High pointing stability
- Know-how in handling high peak power
- We implemented important improvements:
  - Pulse shaper
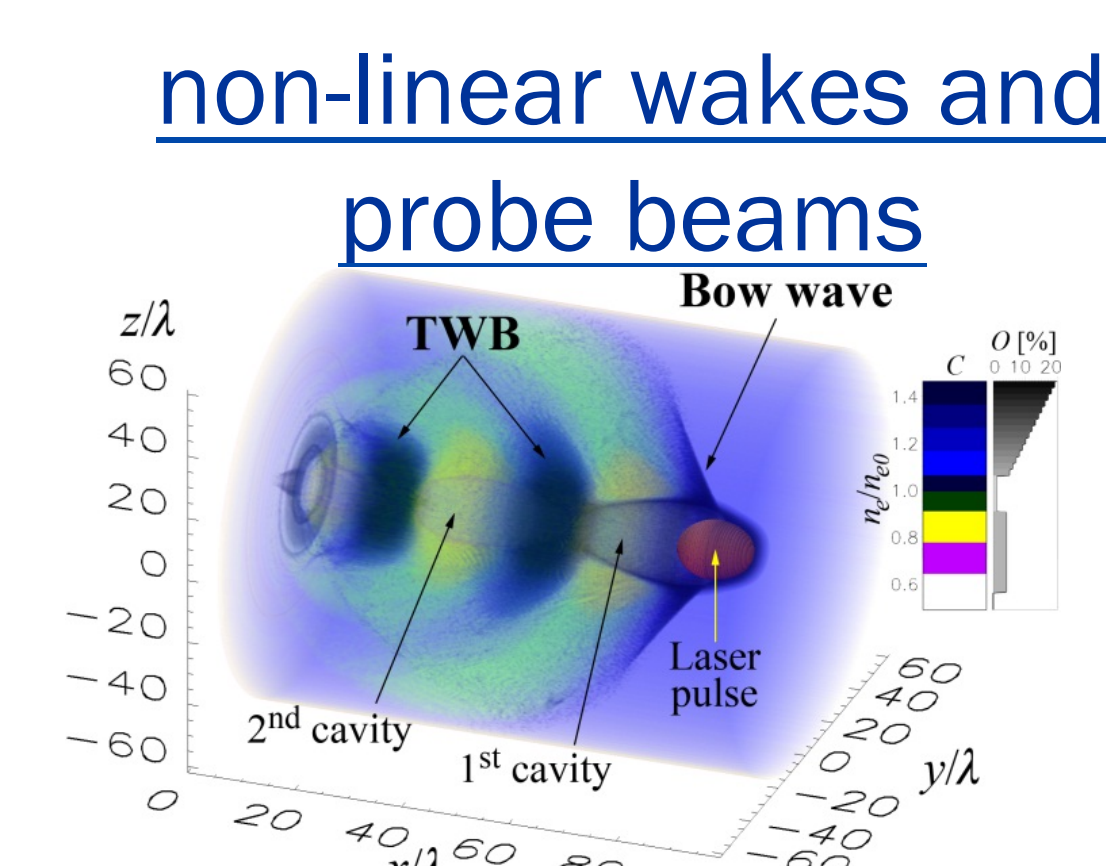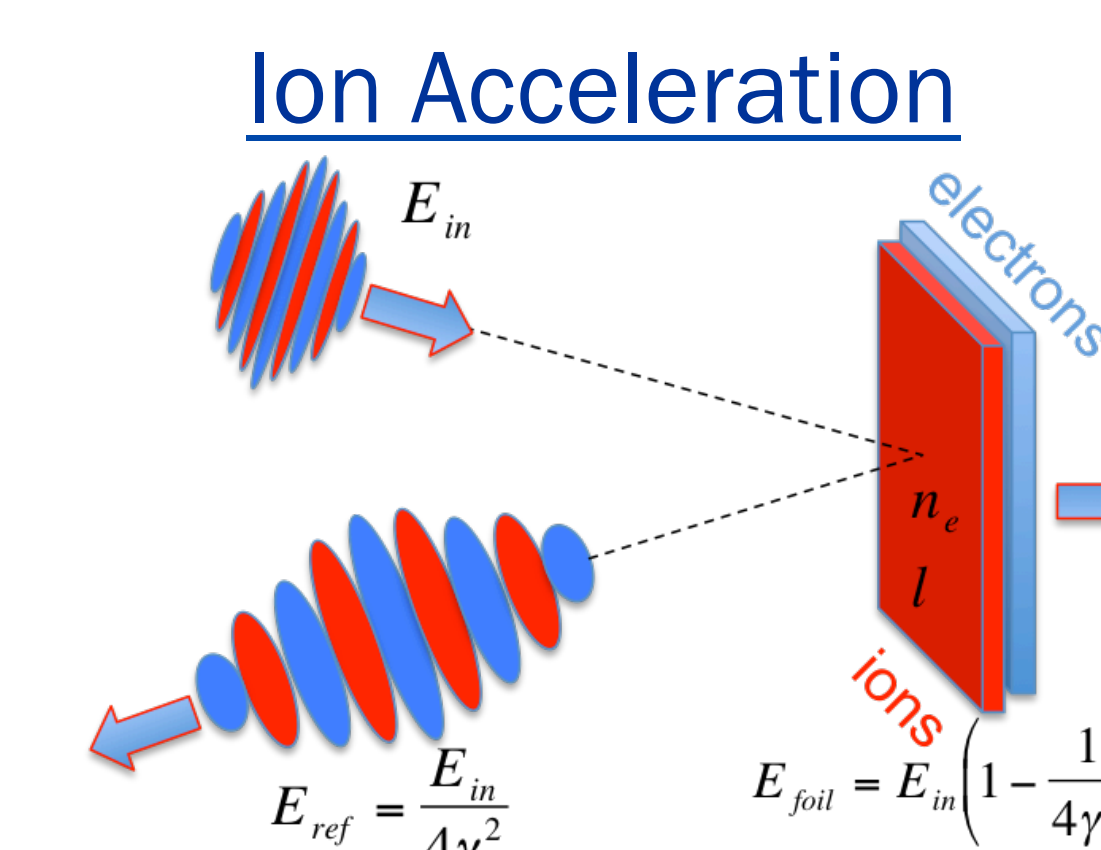 - Ultra-stable oscillator and regenerative amplifier pump

30 TW/J w/ Dazzler

For electron acceleration, the BELLA beam is focused with long focal length, and for ions we need a short focal length and plasma mirrors
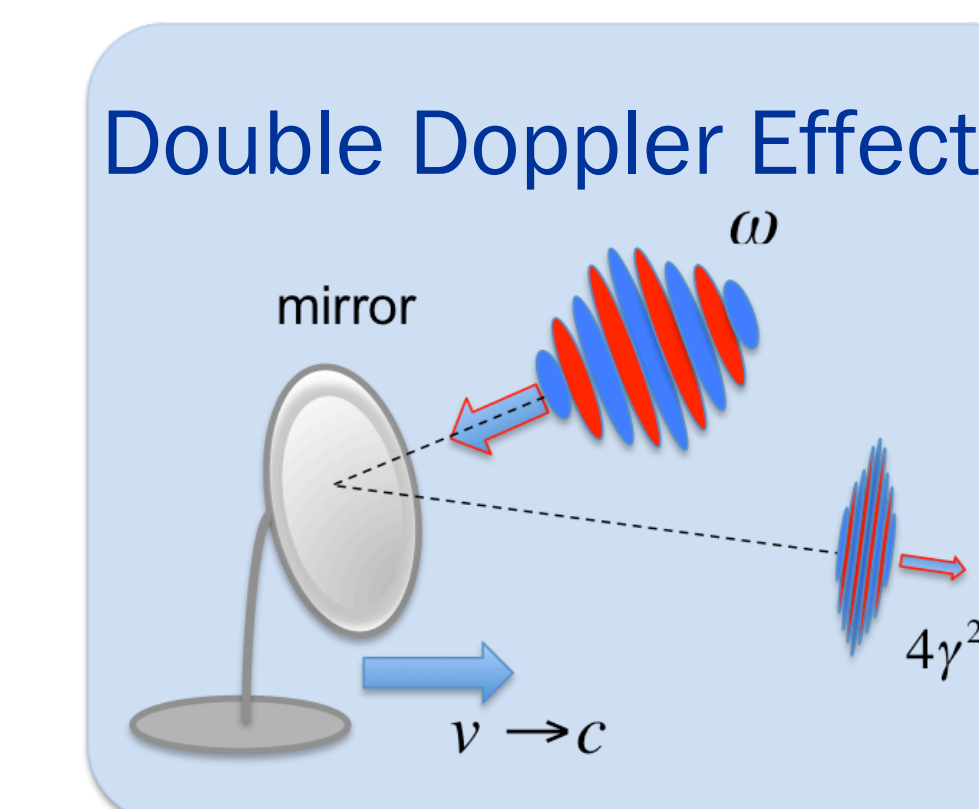
Electron acceleration

Intensity ~1.5×10^{19} Wcm^{-2}
Acc. fields ~10-50GV/m

13.5m

55 micron spot

Ion acceleration

Intensity >3×10^{21} Wcm^{-2}
Acc. fields ~TV/m

<1m

4-5 micron spot

Plasma mirror technology for contrast clean-up

incoming Laser
OAP 1
PM 1
transmitted ASE
OAP 2
PM 2

We propose to add a short focal length capability for ultra-high intensities and to expand BELLA to a user facility

Berkeley Lab Laser Accelerator (BELLA) Center
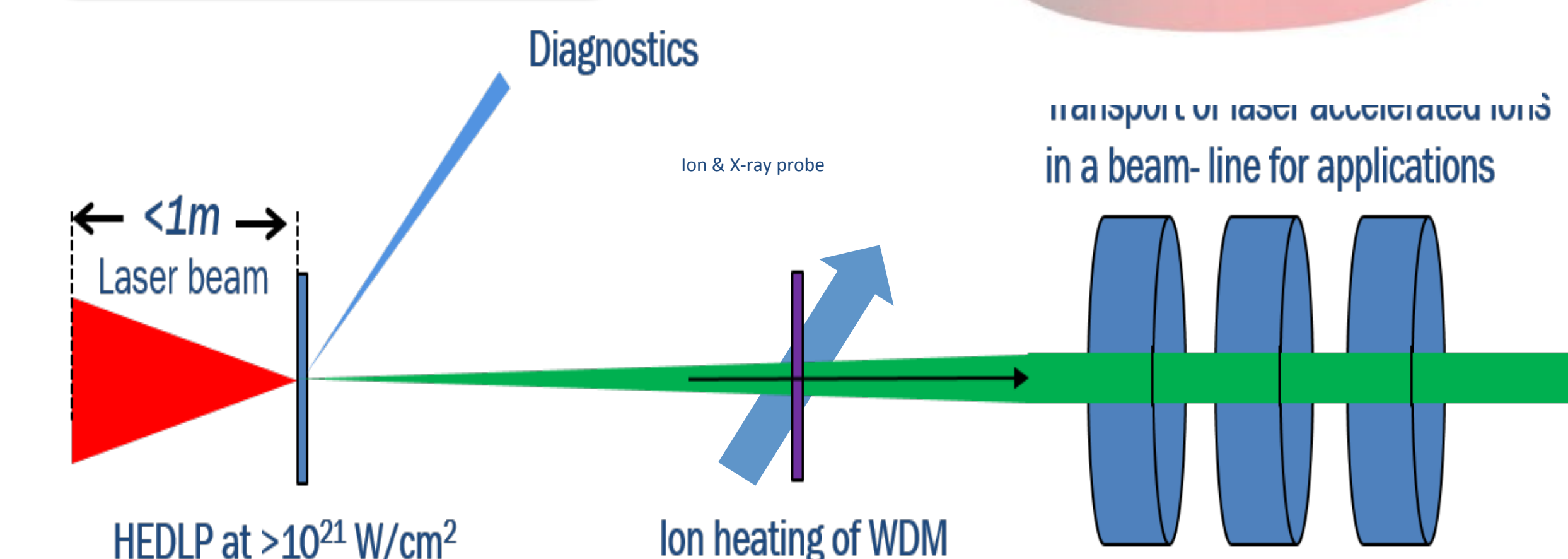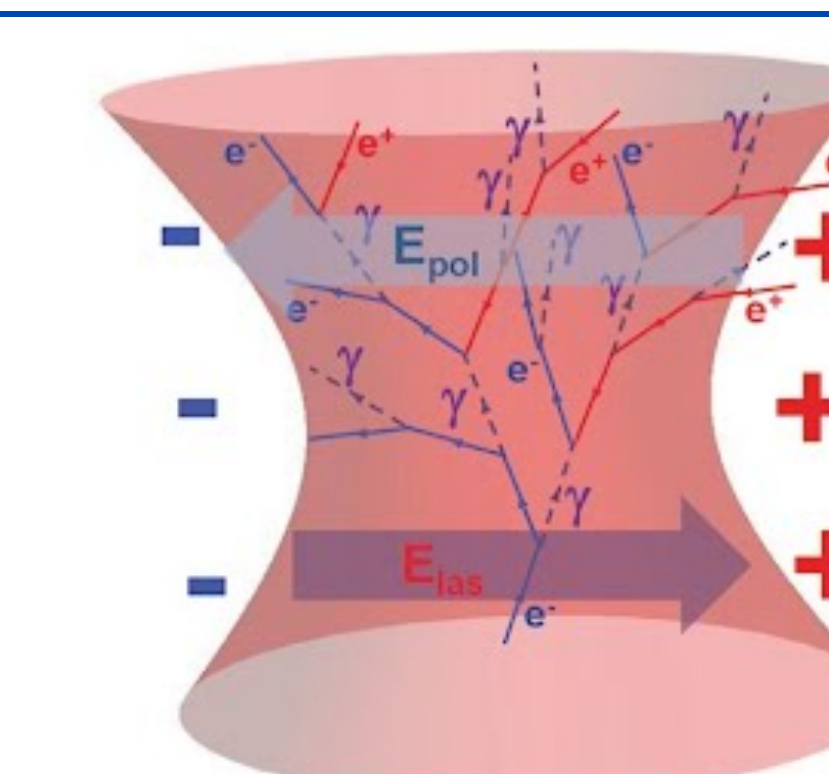

BELLA-i initiative

BELLA-i will enable users to conduct unique experiments in high energy density physics, warm dense mater, ion acceleration (>100 MeV), nonlinear QED effects in ultra-high fields, ...

Ion Acceleration

E_{in} — electrons — ions

$E_{ref} = \frac{E_{in}}{4\gamma^2}$ $E_{fwd} = E_{in}\left(1 - \frac{1}{4\gamma^2}\right)$

non-linear wakes and probe beams

TWB   Bow wave
2nd cavity   1st cavity   Laser pulse

Relativistic Flying Mirrors

High Intensity Particle Physics and the onset of nonlinear QED

Double Doppler Effect

mirror ω
$v \rightarrow c$ $4\gamma^2\omega$

Diagnostics

Ion & X-ray probe

Transport of laser accelerated ions in a beam-line for applications

<1m
Laser beam

HEDLP at >10^{21} W/cm^2 Ion heating of WDM

- We would like to hear from potentially interested users of BELLA-i
- Please contact us for more information or questions
  - WPLeemans@lbl.gov
  - EHEsarey@lbl.gov
  - T_Schenkel@LBL.gov
  - SSteinke@lbl.gov
  - SBulanov@lbl.gov
  - QJi@lbl.gov
- Please let us know if you would like to be added to the BELLA-i mailing list
- http://bella.lbl.gov/